

used with demonstrated accuracy and precision. The purpose of our earlier publication (2) was to make a special plea for the adoption of these procedures so that the data could be more meaningfully compared on an interlaboratory basis for epidemiologic studies.

We were disappointed that these authors did not fully appreciate this as a useful procedure. This was somewhat surprising since Hinners and Simmons (3) had sagaciously recognized an error in our writing, where the word *higher* was substituted for the word *lower*; which was overstated as serious criticism, but has been corrected in the literature (4).

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Thank you for the opportunity to publish a rebuttal letter in *Environmental Health Perspectives*, 10.

We gladly accept Dr. Sorenson's gratitude (1) for our correction (2) of his publication (3). To be considered sagacious by both

Dr. Sorenson and Dr. Petering is indeed an honor. We are further indebted to them (and to the Editor) for this opportunity to clarify comments in our publication (4).

Since the metals considered in the report by Sorenson et al. (4) are not subject to ionization interference as measured (5-7), it is surprising that these authors, after agreeing (1) with our correction (2), still consider an evaluation of ionization interference in their publication (3) to be pertinent.

We suggest that the conflict between our view and the view of Sorenson and Petering on the method of standard additions is based on semantics rather than logic. Since Sorenson et al. (3) used the method of standard additions for calibration in their recovery tests, they compensate for any interference in measurement of the added analyte. Consequently, the term "recovery" in their discussion refers only to physical loss of the added analyte *before* the actual measurements. Since we calibrated (4) on standard solutions *per se*, we use the term "recovery" to encompass interference effects in the measurements.

As a consequence of this semantic difference, our comments (4) and the comments of Sorenson and Petering on the method of standard additions, while equally logical, appear to be contradictory. By our definition of "recovery," use of the method of standard additions is "redundant" (4) when recovery tests have demonstrated that interferences are absent. But since the recovery tests as conducted by Sorenson et al. (3) do not reveal interferences, their comparative use of the method of standard additions is appropriate. In the context of the terminology used by Sorenson et al. (3), our recovery tests do seem confusing. However, our recovery tests do not constitute use of the method of standard additions because we did not calibrate on the response differences between fortified and unfortified samples. In addition, since the method of standard additions is a calibration procedure, it does not *per se* indicate

when interference is present. Only when these results are compared with data obtained by another calibration technique can this data be used to assess the presence or absence of interferences.

We deliberately designed our recovery tests (4) to evaluate only potential interferences on the belief that physical loss of the metals considered was not a realistic concern in a procedure that involved soaking the hair in a single reagent at room temperature in a closed container. The literature provides ample evidence that losses of these metals are not encountered when biological specimens are digested with hot acids. If we had encountered incomplete recoveries in our tests, use of the method of standard additions would have been necessary, if the interference could not be eliminated.

The preferable definition for a term is often a debatable issue. In support of our usage, we submit that it is preferable to evaluate the need for an involved calibration procedure before utilizing it. In addition, limiting the term "recovery" to mean only physical loss of an analyte *before* the actual measurement seems arbitrary since chemical and ionization interference in atomic absorption are also forms of physical loss involving the measurable species. Delves agrees with our terminology, since he has succinctly observed (8) that "recovery tests are meaningless" when calibration is conducted by the method of standard additions. Reporting interference recovery tests after calibrating by the method of standard additions is analogous to calculating a defined quantity.

Although Sorenson and Petering consider our separate tests for chemical and ionization interference redundant, we concur with Willis (9) that adding standards to specimens in order to control or evaluate interferences is limited because it is: "based on the assumption that the interfering material alters the absorbance of the added metal to the same degree as it does that of the metal in the original sample. This may not always be so, particularly when only a small amount of the interfering material is present."

Sorenson and Petering are correct that "absence" appears in our report (4) where "absent" was intended. Among other corrections needed are: (1) page 195, line 24, "Cu > Zn" for "Cu < Zn"; (2) page 195, line 12, "internally inaccessible" after "significant"; (3) page 196, line 1, "(62,63)" after "reported"; (4) page 198, ref. 22, "Klevay" for "Kelvay"; (5) page 198, ref. 37, "85: 143" for "143: 85."

Since our report (4) was published, we have learned of an interesting study by Kopito et al. (10) that revealed an abnormally high release of hair calcium (to boiling water) for specimens obtained from patients with cystic fibrosis. An altered protein binding of calcium may be the "basic defect in cystic fibrosis" (10). Carboxyl groups in hair and other proteins may be involved in this calcium binding difference since calcium ions do not readily bind to sulfur in dithiocarbamates (11) nor to nitrogen or oxygen in amide resins (12). But calcium ions do bind readily to tetracarboxylic EDTA (12) and to a calcium-sequestering protein (14) in which 37% of the amino acid residues are either aspartic or glutamic acid. As noted in our report (4), these two dicarboxylic acids constitute about 19% of normal hair and only one of the carboxyl groups is needed (for conversion to an amide bond) in protein formation.

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